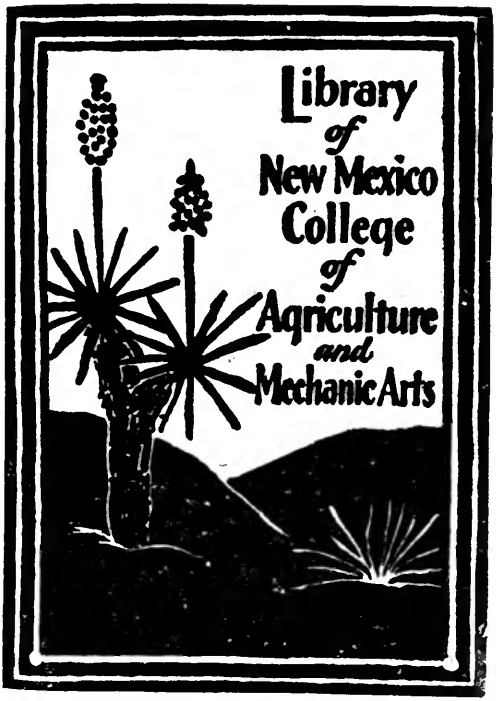

UNIVERSITY OF ILLINOIS,

Agricultural Experiment Station.

CHAMPAIGN, AUGUST, 1890.

BULLETIN NO. 10.

INVESTIGATIONS OF "MILK TESTS."

Experiment No. 106.

The object of the investigation here reported was:

First, To show that dairy cows vary in value to their owners. Some are like weeds in a corn field, and are kept at an actual loss; while others pay for their keeping and a profit besides.

Second, To show that the *pounds* of *milk* brought to a creamery by its patrons is not the most accurate basis upon which to pay for the milk, since the butter fat, which alone is of value to the creamery, is not always proportionate to the quantity of milk.

Third, A trial of some of the methods proposed for analyzing or testing milk, that can be easily and quickly mastered by those who wish to use them; and observations on the accuracy of results obtained by these methods.

No dairyman, farmer, nor any one that keeps a cow for her milk, needs to be convinced that one of the best, if not the best basis to be used in calculating the profit and loss per cow, is the per cent. of fat in her milk, or the pounds of butter fat in 100 pounds of milk. Other things being equal, the most profitable cow is the one that converts a given amount of feed into the most butter fat; and when the owner of a herd of milch cows is provided with a trustworthy "milk tester" or method by which he can determine the per cent. of fat in each cows milk, then he is able to weed out the unprofitable cows in his herd and get larger returns with much less labor.

In the first division of this investigation the per cent. of fat was determined in the milk of each cow on three different farms, where, at that season, the cows had pasture feed only.

The cost of keeping a cow is an item not at all considered here, as each individual owner is the one best supplied with facts and figures from which to make that calculation for his own locality.

The following table gives a record of the cows tested. It shows a striking variation, and how owners of cows could calculate the profit and loss per cow, if, in addition to the per cent. of fat, they knew the pounds of milk produced by each cow during the year.

Although somewhat limited, this is given as a beginning of work to be more extensively followed up, in the hope that such an illustration may suggest to those interested a way of becoming so acquainted with their cows and business that the cause of success or failure can be better understood each year.

RECORD OF TESTS MADE OF MILK TAKEN AT ONE MILKING FROM 38 COWS ON THREE FARMS.

No.	Breed.	Age, years.	Date of last calf.	Days since last calf.	Pounds of milk.	Per cent. of fat.	Pounds of fat.
	Farm A—Evening of June 17, 1890.						
1	Holstein, half	4	Jan., '90.	150	7.5	4.3	0.32
2	Devon, half	5	Oct., '89.	240	14.5	3.7	0.54
3	Shorthorn	6	Oct., '89.	240	7	3.8	0.27
4	Shorthorn, grade	7	Jan., '90.	150	4.5	4.8	0.22
5	Holstein, three-fourths	10	Sept., '89	270	7.5	3.4	0.25
6	Shorthorn, half	11	Nov., '89.	226	6.5	4.2	0.27
7	Shorthorn, grade		Sept., '89	285	3	5.1	0.15
8	Native	12	Oct., '89.	240	4.5	2.3	0.10
9	Devon, three-fourths	12	Oct., '89.	240	15.5	3.5	0.54
10	Shorthorn, grade	8	Oct., '89.	240	12	4.0	0.48
11	Shorthorn, grade	9	Aug., '89.	300	4.5	4.6	0.21
12	Native	9	Sept., '89	270	9.5	2.4	0.23
13	Native	12	Nov., '89.	211	5.5	4.2	0.23
14	Holstein, grade	6	Oct., '89.	240	10.5	2.3	0.24
15	Jersey, registered	3	Sept., '89		8	5.0	0.40
16	Native	10	Sept., '89	270	14.5	2.5	0.36
17	Jersey, registered	4	June, '89.		8.5	6.0	0.51
	Farm B—Morning of June 18, 1890.						
18	Jersey, seven-eights	7	May, '89.	395	9	5.5	0.49
19	Jersey, fifteen-sixteenths	4	May, '89.	395	14	4.0	0.56
20	Jersey	2	Dec., '89.	180	6	5.6	0.34
21	Jersey	2	Feb., '90.	130	8.5	4.9	0.42
22	Jersey, fifteen-sixteenths	6	Oct., '89.	240	19	4.0	0.76
	Farm C—Evening of June 18, 1890.						
23	Holstein, grade	2	April, '89	426	3	4.5	0.14
24	Holstein, grade [three-eights	4	Sept., '89	270	10	4.2	0.42
25	Holstein, half; Jersey,	3	Nov., '89	225	9	3.4	0.31
26	Holstein, grade	2	Dec., '89	180	5.5	3.8	0.21
27	Jersey, half	15	Sept., '89	270	6.5	5.0	0.32
28	Holstein, grade	2	May, '90.	45	14	2.3	0.32
29	Holstein, grade	2	May, '90.	45	11.5	3.5	0.40
30	Holstein, grade	20 mos.	April, '90	50	6.5	3.4	0.22
31	Holstein, grade	2	June, '90.	14	15	3.2	0.48
32	Polled Angus	2	June, '90.	14	9.5	3.6	0.34
33	Holstein, grade	20 mos.	May, '90.	45	6.5	3.9	0.25
34	Holstein, grade	2	April, '90	60	9	2.6	0.23
35	Holstein, grade	20 mos.	May, '90	45	7	3.5	0.24
36	Holstein, grade	Yearling			7	3.0	0.21
37	Holstein, grade	Yearling			7.5	3.4	0.25
38	Holstein, grade	Yearling			6.5	5.0	0.32

This table represents a record of one milking of 38 cows. It includes cows from twenty months to fifteen years old, that had been milked from 14 to 426 days since calving. Such a record as this increases in value with the number of days, weeks, and months it is kept up; and, as analyzing or testing milk for the amount of fat in it is now within the reach of any man, no one need be satisfied with keeping anything but profitable cows. The figures in this table showing the number of days milked, are not exact; but for purpose of this investigation they are near enough to the truth.

It should be kept in mind that the "pounds of fat produced" is for only one milking.

In comparing cows for their butter value, obviously, those should be selected that calved at about the same time, so that the conditions may be the same.

If we compare Nos. 2, 3, 22, and 8, we find that No. 2 produced twice as much butter fat as No. 3, and nearly five and one-half times as much butter fat as No. 8, and that No. 22 produced seven and one-half times as much butter fat as No. 8.

Comparing No. 13 with No. 14 shows that nearly twice as much milk must be handled by the owner to get the same weight of butter fat from No. 14 as from No. 13. Besides these extreme cases mentioned, cows can be found all along the line from very profitable to very unprofitable.

Taking up now the second division of the investigation:

The relation of the quantity of milk supplied by each patron to the total amount of butter fat produced by the creamery could be quite definitely determined, if, together with the pounds of milk furnished, it were known in each case what per cent. of fat the milk contained. To illustrate this, the milk brought during one day by each patron to two creameries was analyzed, 113 tests being made.

The following table contains the record.

The table shows that at creamery A the milk brought by one-fifth of the patrons contained 3.6 per cent. fat, or 27.7 lb. milk to 1 lb. of butter fat. The amount they brought was nearly one-seventh (14.7 per cent.) of the total receipts of milk, and the butter fat it contained was about one-seventh (14.4 per cent.) the total amount received. In this case, then, it did not make much difference with one-fifth of the patrons whether they were paid per hundred lb. of milk or per lb. of butter fat delivered, as each is nearly the same proportion of the total quantity for the day. With the other four-fifths of the patrons, however, the proportion is quite irregular. The milk brought by 24 patrons, or nearly one-half of all, was 49.7 per cent. of the total quantity, but it contained from 3.7 to 4.0 per cent. of fat and supplied 51.9 per cent. of the total butter fat. One-fourth of the patrons delivered 26.5 per cent. of the total milk brought; but it contained from 3.2 to 3.5 per cent. of fat and supplied only 24.3 per cent. of the total butter fat that day.

RECORD OF TESTS MADE OF MILK BROUGHT BY 113 PATRONS TO TWO CREAMERIES IN ONE DAY.

Per cent. fat in milk.	Creamery A—June 16, 1890.				Creamery B—June 18, 1890.			
	Pounds milk.	Pounds fat.	Pounds of milk per pound of fat.	No. of patrons contributing.	Pounds milk.	Pounds fat.	Pounds of milk per pound of fat.	No. of patrons contributing.
2.3	.....	.....	.....	.....	202	4.64	43.5	1
2.5	.....	.....	.....	.....	31	0 77	40	1
2.6	.....	.....	.....	.....	36	0.93	38.4	1
2.9	.....	.....	.....	.....	181	5.25	34.5	2
3	173	5.19	33.3	1	.....	.....	.....	.....
3.1	250	7.75	32.2	1	252	7.81	32.2	1
3.2	546	17.47	31.2	3	888	28.41	31.2	6
3.3	1,188	39.20	30.3	3	1,010	33.33	30.3	6
3.4	848	28.83	29.4	4	2,123	72.18	29.4	9
3.5	826	28.91	28.5	4	628	21.98	28.5	4
3.6	1,886	67.89	27.7	11	1,555	55.98	27.7	9
3.7	2,169	80.25	27	8	853	31.56	27	6
3.8	2,148	81.62	25.3	9	1,178	44.76	26.3	6
3.9	1,044	40.71	25.6	4	448	17.48	25.6	2
4	1,020	40.80	25	3	412	16.48	25	2
4.1	198	8.12	24.4	1	.....	.....	.....	.....
4.2	111	4.66	23.8	1	316	13.27	23.8	1
4.3	277	11.61	23.2	1	.....	.....	.....	.....
4.4	150	6.60	22.7	1	.....	.....	.....	.....
4.6	.....	.....	.....	.....	162	7.45	21.7	1
	12,834	469.61	27.33	55	10.273	362.23	28.36	58

Besides these already mentioned are a few extremes. The milk supplied by two patrons contained 3.0 and 3.1 per cent. fat, and that supplied by four patrons, from 4.1 to 4.4 per cent. fat, making a difference of 1.4 per cent. between extremes; or the richest milk was 47 per cent. richer than the poorest.

Equally striking illustrations could be drawn from the record of creamery B. Eighty per cent. of the patrons supplied milk ranging from 3.2 to 3.8 per cent. of fat, but the milk brought by one patron ran as low as 2.3 per cent. and that brought by another as high as 4.6 per cent. of fat; that is, one contained just twice as much butter fat in 100 lb. of milk. If the richer milk is received at $1 per 100 lb., for the poorer but 50 cts. per 100 lb. should be paid.

In the third division of this investigation an examination was made of five methods or systems, proposed during the last two years, to be used for analyzing or testing milk by persons not chemists.

1. "A new method for determining fat in milk," by F. G. Short. (*Bulletin No. 16, July, 1888, A. E. S., Univ. of Wis.*)

By this method the fat in milk is saponified by heating two hours with alkali, the insoluble fatty acids separated by boiling one hour with a mixture of equal parts commercial sulphuric and acetic acids and measured at a temperature of about 150° F., it being assumed that the insoluble fatty acids constitute 87 per cent. of the total fat in milk.

2. "A new volumetric method for the estimation of fat in milk, skimmed milk, buttermilk, and cream," by C. L. Parsons. (*Ann. Rep't, N. H. A. E. S., 1888, p. 69.*)

By mixing the milk to be analyzed with alkali, alcholic soap, and gasoline, the fat is dissolved and rises to the surface in a layer of gasoline after standing some time. An aliquot part of the gasoline layer is heated at 245° F.to 250° F. for one hour and a half. This evaporates everything but the fat, which is measured in apparatus specially devised for the purpose.

3. "A new method of milk analysis for the use of dairymen," by G. H. Failyer and J. T. Willard. (*Ann. Rep't Kas. A. E. S., 1888, p. 149.*)

The curd of milk is dissolved by heating with concentrated commercial hydrochloric acid, the fat collected as a whole by solution with gasoline, then gasoline evaporated and the separated fat measured in the same tube in which the reactions are made.

4. "A new process for determining the per cent. of fat in milk, cream, or skim milk," by C. B. Cochran. Patented. (*Jour. Analytical Chemistry, Vol. III., p. 381.*) Can be had of Cochran & Marshall, Philadelphia.

In a flask especially devised for the purpose, the milk is heated at the temperature of boiling water with an equal quantity of a mixture of one-half commercial sulphuric acid and one-half glacial acetic acid. Washed ethyl ether is then added, and after all ether has been driven off by heat, the fat which has separated is forced into the measuring tube of the apparatus by adding hot water till the flask is full.

5. "The Iowa Station milk test," by G. E. Patrick. (*Bull. 8, Ia. A. E. S.*) Can be had of J. F. McLain, Ames, Ia.

Milk to be "tested" is boiled with an acid mixture composed of 90 per cent. acetic acid, commercial oil of vitriol, and hydrochloric acid, c. p. This acid mixture is saturated with sulphate of soda. The fat separates, rises to the surface of the liquid, and is measured in the graduated portion of the tube. The amount of milk taken for the analysis bears such a relation to the graduations of the tube in which the fat is measured, that the measure of the fat represents the per cent. of it in the milk.

The necessary special apparatus was obtained for carrying on each one of these methods, and analyses were made of a great many samples of milk. The table of analyses, p. 235, gives results obtained by the methods that proved, in use here, most simple, practical, and accurate. With the original description of each method a sufficient number of results are given to show them to be reasonably accurate.

Assuming that all these methods give equally accurate results, the last two—Cochran's and Patrick's—especially commend themselves by the rapidity and ease with which the details can be comprehended and a sample of milk analyzed by almost any careful person, though not accustomed to such work. With each method, directions for using it are given; but any one wishing practical instruction in the manipulation and use of the apparatus, may find it to his advantage to visit the laboratory of this

Station, where an opportunity will be given him for instruction in the process.

The following table shows some observations made on the methods:

TABLE SHOWING MILK, CHEMICALS, TIME, AND COST OF CHEMICALS REQUIRED FOR EACH ANALYSIS.

Method of,	Milk per analysis, c. c.	Re agents or chemicals used.	Time for single analysis, approximate.	Estimated cost for chemicals, per analysis.
Short.	20	Alkali, 10 c. c. (Potash and soda.) Acid, 10 c. c. (Sulphuric & acetic.)	Three and one half hours.	
Parsons.	100	Alkali, 10 c. c. (Soda.) Alcoholic soap, 5 c. c. Gasoline, 50 c. c.	Two and one-half hours.	
Failyer & Willard.	10	Hydrochloric acid, 8 c. c. Gasoline, 15 to 20 c. c.	One-half hour. "Four analyses in one and one-fourth hours."	
Cochran.	5	Acetic acid, 2.5 c. c. Sulphuric acid, 2.5 c. c. Ethyl ether, 4 c. c.	One-half hour. "Twenty four analyses in one and one fourth hours."	"About one-half cent."
Patrick.	10.4	Acid mixture,* about 15 c. c.	About 20 minutes. "Six analyses in one-half hour."	†Acid mixture, 25 cts per lb.

*Acetic acid (99 per cent.), 9 volumes. Commercial oil of vitriol, 5 volumes. Hydrochloric acid, c. p., 2 volumes. Saturate with sulphate of soda.

†Assuming each analysis uses 18 gr. acid mixture, the cost per analysis is about 1 cent.

OBSERVATIONS AND PRECAUTIONS NECESSARY TO OBTAIN MOST ACCURATE RESULTS IN USING EITHER METHOD OF ANALYSIS.

Test the accuracy of the measuring part of the apparatus by making an analysis of the same sample of milk in each tube or flask. If the same per cent. of fat is found in each case, the graduation is probably correct.

Read the divisions on the tube that the fat occupies after it has stood at least fifteen minutes in water at a temperature of 140° F. (60° C.)

Keep in mind the necessity of allowing time enough for all the hot fat to accumulate in the measuring tube, and also, that by transferring the flask or tube from a boiling heat to 140° F. the liquid below the fat will cool and occupy less space so that the column of fat may fall below the graduations of the measuring tube.

Unless the glass tube or flask used in the analysis is carefully cleaned, globules of fat will be seen sticking to the sides of the glass. By using hot water and a bristle swab, the glass can be so cleaned that its smooth surface will allow the hot fat to move in an unbroken mass.

In Cochran's method, the liquid often foams badly when hot water is added to raise the fat into the measuring tube. This may be caused by

carbonic acid in the water and can be prevented by adding a few drops of some acid (sulphuric, nitric, etc.) to the water before heating it for this purpose.

Outside of the correct graduation of the measuring parts of the apparatus, the accuracy of the results obtained by using such methods as these, depends, to a controlling degree, on constant attention to such small details as measuring the fat in clean glass, and carefully and uniformly reading and recording the length of the fat column.

Estimating the per cent. of fat in buttermilk by these two methods is not always accurate, as will be seen by the analyses given in the table. With Cochran's method a separation of the fat from buttermilk is nearly always obtained. The separation by Patrick's process is greatly helped by boiling the milk and acid somewhat longer than usual, adding about 5 c. c. of ether when the mixture is cool, and then bringing it to a boil by heating gradually till the ether is all evaporated.

The following table shows results of analyses made by these methods. When more than one analysis was made of a sample of milk by the same method, sometimes an average of the two or more analyses is given:

PER CENTS. OF FAT FOUND IN WHOLE MILK, SKIM MILK, AND BUTTERMILK WHEN ANALYZED BY METHODS NAMED.

Milk of,	Extraction with ether.		Patrick.	Cochran.	Short.
	On sand.	On paper.			
	Whole milk.				
			3.12		
			3.05		
	3.07		3.08		
Herd	3.11		3.00		
Average	3.09		3.06		
	4.59		4.50	4.67	
One cow	4.46		4.80	4.50	
Average	4.52		4.65	4.58	
One cow	3.70	3.60	3.70	3.60	
One cow	3.77	3.78	3.70	3.76	
One cow	4.33	4.28	4.20	4.15	
One cow	4.78	4.80	4.70	4.67	
One cow	4.13	4.06	4.10	3.97	
			4.60		4.78
			4.55	4.50	4.88
	4.69	4.58	4.69	4.55	4.88
One cow	4.71*	4.59	4.60	4.67	4.88
Average	4.70	4.59	4.59	4.57	4.85
			4.00	3.97	3.86
One cow	3.88*	3.96	4.00	4.15	3.97
Average	3.88	3.96	4.00	4.03	3.91
			4.20	4.15	4.68
One cow	4.30	4.40	4.20	4.15	4.58

PER CENTS. OF FAT, ETC., *Continued.*

Milk of,	Extraction with ether.		Patrick.	Cochran.	Short.
	On sand.	On paper.			
	Skim milk.				
	0.57		0.80	0.69	
Lab. No. 234	0.62		0.80	0.69	
Average	0.59		0.80	0.69	
241	0.48	0.48	0.60	0.48	
	0.66				
242	0 68*		0.70	0.69	
		0.94			
250	0.94	0.97	0 80	0.79	
			1.40		1.12
			1.30	1.27	1.12
252	1.23	1.28	1.30	1.38	1.12
	1.52		1.30	1.27	1.12
Average	1.38		1.32	1 31	1.12
261		1.88	1.90	1.90	1.88
	Buttermilk.				
	0 37		0 00		
235	0.37		0.00	0.34	
			0.00	0.00	
239	0.46	0.47	0.35	0.32	
		0.87	0.00	0.00	
249	0.81	0.90	0.60	0.93	0.80
		0.39	0.2	0.34	
253	Lost.	0.40	0.2	0.34	
			0.5		
258		0.96	0.5	0.69	0.40

*Asbestos.

E. H. FARRINGTON, M. S.,
Assistant Chemist.

All communications intended for the Station should be addressed, not to any person, but to the

AGRICULTURAL EXPERIMENT STATION, CHAMPAIGN, ILLINOIS.

The bulletins of the Experiment Station will be sent free of all charges to persons engaged in farming who may request that they be sent.

SELIM H. PEABODY,
President Board of Direction.